Heliophysics Technology And Instrument Development For Science

The relation of laboratory-generated whistler-mode waves and whistler-mode chorus waves in space

Completed Technology Project (2016 - 2019)

Project Introduction

1. Introduction Chorus waves are naturally-occurring whistler-mode waves found in the near-Earth space environment, that are typically observed as discrete, coherent emissions in the frequency band between ~0.1 fce and ~0.8 fce, where fce is the equatorial electron gyrofrequency. Recent observations made by NASA's Van Allen Probes and THEMIS missions have demonstrated that chorus waves play a critical role in creating the relativistic and ultra-relativistic radiation belts the encompass the Earth, as well as important phenomena the impact ionospheric conductivity such as the diffuse and discrete auroral emissions. Despite its recognized importance, the mechanisms that control the basic characteristics of the chorus waves are still poorly understood, or not understood at all. These parameters include the lower and upper frequency limits of the chorus wave, the chirp rate (df/dt), the saturation amplitude, and the wave normal angle of the wave, as a function of frequency. There is not first-principles understanding available of what controls these parameters, yet modelers must put some of these values into their codes using heavy assumptions, in order to calculate diffusion coefficients that control radiation belt dynamics. A recent set of experiments performed by our group at the Large Plasma Device (LAPD) at UCLA has demonstrated that it is possible to produce whistler-mode "chorus" waves in a laboratory plasma, having all the characteristics of naturally occurring chorus waves in space. This is a breakthrough experiment and gives us the ability to carefully measure and understand the parameters that control the chorus wave characteristics. 2. Science goals and objectives The goal of our proposed project is to perform comprehensive measurements and parameter studies at the LAPD at UCLA to understand the basic parameters that control the various chorus wave characteristics, compare our experimental results with linear theory and PIC code simulations, and ultimately test our newfound understand against in-situ observations in space. 3. Brief description of the methodology We excite chorus wave in the LAPD using a LaB6 electron source the creates a fast-electron beam with 3-4 keV energies, propagating through a cool (~1 eV) background plasma. This beam is tilted at an angle to the background B-field, and both the beam and resulting waves are measured several meters further down in the plasma column. We have comprehensive linear and Particle in Cell codes that support the analysis of the measured wave, and the full set of measurements from the (currently operating) THEMIS and Van Allen Probes missions, to compare our lab observations to in-situ observations made in space. Our group has extensive experience in all aspects of this project, including the laboratory experiments, the linear/PIC theory, and observations in space. 4. Relevance to NASA H-TIDes program Consistent with the LNAPP program element, we believe that our proposed project is high relevant and [to quote directly from page B.3-4,5] "The LNAPP program supports studies that … provide benchmarks for integrating theory and modeling with observation in solar and space physics. Laboratory experiments allow the use of a controlled environment to perform reproducible measurements that shed light on key processes with the Heliophysics environment. These experiments

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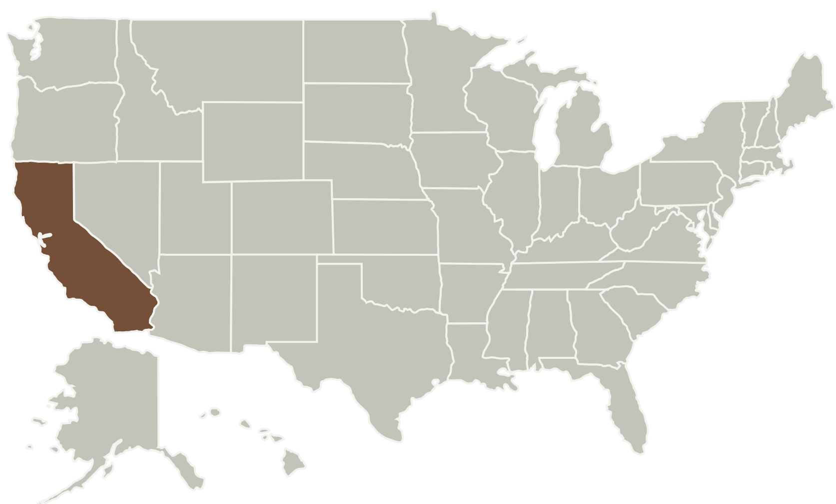
are directed toward understanding basic processes.”

Anticipated Benefits

Support NASA’s strategic objectives to understand the Sun and its interactions with Earth and the solar system, including space weather. This will be achieved by developing/demonstrating instrumentation technology necessary to address the following science goals:

- Explore the physical processes in the space environment from the Sun to the Earth and throughout the solar system;
- Advance our understanding of the connections that link the Sun, the Earth, planetary space environments, and the outer reaches of our solar system;
- Develop the knowledge and capability to detect and predict extreme conditions in space to protect life and society and to safeguard human and robotic explorers beyond Earth.

Primary U.S. Work Locations and Key Partners



Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Organization:

University of California-Los Angeles (UCLA)

Responsible Program:

Heliophysics Technology and Instrument Development for Science

Project Management

Program Director:

Roshanak Hakimzadeh

Program Manager:

Roshanak Hakimzadeh

Principal Investigator:

Jacob Bortnik

Co-Investigators:

Bart Van Compernolle
Richard M Thorne
Shauna Huntsman
Wen Li
Walter N Gekelman

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Organizations Performing Work	Role	Type	Location
University of California-Los Angeles(UCLA)	Lead Organization	Academia	Los Angeles, California
University of Southern California(USC)	Supporting Organization	Academia Asian American Native American Pacific Islander (AANAPISI)	Los Angeles, California

Primary U.S. Work Locations
California

Technology Maturity (TRL)

Start: **3**
Current: **3**
Estimated End: **5**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.3 Optical Components

Target Destination

The Sun